International Journal of Humanities, Arts and Social Sciences
volume 5 issue 6 pp. 224-231 doi: https://dx.doi.org/10.20469/ijhss.5.20002-6

Risk Identification and Management in Construction Projects: Literature Review

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Abstract: The significance of risk management has increased in the last few years, and the Critical Risk Factors (CRFs) have attained more attention from the construction industry practitioners. Huge and complicated construction projects contain a lot of risk factors, and the completion of these projects relies on the proper management of the main risks. This paper identifies the critical risk factors associated with construction projects along with the most commonly used risk identification techniques and methods of classifying risks. For this study, a total of sixty-seven risk factors were identified through an in-depth content analysis of the literature. The method used for ranking critical risks, risk identification techniques, and classifying risk was based on the number of articles considering that particular risk, technique, and method. The top five identified risks were unavailability of funds, design errors & poor engineering, poor site management & supervision, contractual risks, change in laws and regulations. The most commonly used risk identification technique and method of classifying risk was the questionnaire survey and nature of the risk. The research findings are helpful to engineers, supervisors, project managers, and construction practitioners for early assessment and proper management of risks present in construction projects.

Keywords: *Risk management, critical risk factors, risk identification, risk classification, construction project*

Received: 13 October 2019; ***Accepted:*** 30 November 2019; ***Published:*** 27 December 2019

INTRODUCTION

Risk in the construction is unavoidable because of the complex dynamic environment in which construction work has to be performed (Akintoye & MacLeod, 1997). As construction activities are uncertainf in nature, therefore, studies affirm that construction is a profoundly hazard inclined industry (Zeng, An, & Smith, 2007). For the successful accomplishment of project objectives and targets, risk should be managed in an effective manner. Risk management has been known as a vital tactic to meet project targets like time, budget, and quality (Han, Kim, Kim, & Jang, 2008; Radya & Budi, 2019). Development ventures are defined by their fluctuating degrees of uniqueness and multifaceted nature, the dynamic association of numerous partners, capital seriousness, dynamic situations, long generation terms, and varying climatic conditions (Taroun, 2014). Risks and vulnerabilities are for sure present in all construction projects from commencement to the accomplishment of the project-irrespective of its size, complications involved, and location of the project.

The purpose of this study is to identify the major risks present in a construction project rather than focusing on all the risks at the same time as it is time-consuming as well as very complicated. For identification of the major

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risk, a in-depth content analysis of literature is done. The top risks are analyzed carefully and ranked according to number of articles considering that risk. This paper compiles all the major findings of previously published articles in a systematic way. The results of this study will help construction practitioners to identify risk related to construction projects before commencement of the projects which will enhance the capability of managing risk in construction projects. Further categorization of risks is done which will help in better allotment of risk responsibilities. The top risks were also categorized on the basis of nature of risk. The significance of this study is that understanding risk involved in construction projects at such an early stage (commencement) of the project will help construction practitioners to manage it in such a way that it has minimum negative effect on project targets and maximum positive results.

RISK MANAGEMENT PROCESS

The main reason that risk management is not that popular among the construction industry is due to insufficient knowledge of risk management framework. It is essential to apply risk management from the commencement of the construction project as knowing the origin of the risk will help practitioners to deal with it in a better way. A lot of research has been done so far on the risk involved in the construction projects, in spite of that construction projects have to deal with various risks like cost-overrun, time-overrun, quality issues, and contractual issues, etc. In this paper literature review of previous research has been done to bring more clarity to the area of risk management in the construction. This paper provides a list of the top 10 risks involved in construction industry, with commonly used risk identification techniques and commonly used methods of classifying risks.

Risk management primarily consists of the following steps: identification of the risk, risk analysis, responding to the risk. Risk identification's purpose is to assess possible risks and their consequences on the project's ability to attain project targets. The identification of risk process should consider both positive risks (opportunities) as well as negative risks (Arunplod, 2019; Hillson, 2002). It may be from within the project or from external sources. Various risk identification techniques are questionnaire surveys, literature review, checklist, documentation review, brainstorming, Delphi technique, case studies of past projects. Common methods used for risk analysis are probability impact matrices, sensitivity analysis, Monte Carlo simulations, tree analysis, using fuzzy methods, etc. Responding to the risk is the process used to mitigate that risk which is involved in a project. Various risk responses are avoiding risk, transferring risk, reduction of the risk, retention of the risk.

LITERATURE REVIEW

For this study of literature review, only those journals were selected which are focused on risk-related articles and have published more than 2 papers on risk in construction. Risk factors involved in construction projects, along with commonly used risk identification techniques and commonly used methods of classifying risk have been reviewed in this paper.

Zhi (1995) studied management of risk for overseas construction projects. Zhi (1995) classified project risks as external risks and internal risks. Risk management process consists of four main stages (a) classification of the risk, (b) identification of the risk, (c) assessment of the risk, and (d) response to the risk. For studying the criticality of risks every risk was judged on two criteria. First was the frequency of occurrence of that risk and second was the severity of the occurrence of that risk on objectives. Ranking of risk was done by multiplication of frequency and severity, i.e., R = P*I. The top five risks identified by Zhi (1995) in overseas construction projects were inflation, bureaucracy, corruption, low social security & lack of education. The response technique used in overseas projects should be according to the type of project, it can also be different for similar projects depending on location and other significant conditions.

Akintoye and MacLeod (1997) focused on analysis of risk & its management in the construction industry. A questionnaire survey was prepared which was filled by contractors in the UK and project managers. The survey forms were distributed to hundred top firms in the UK out of which seventy were contractors and thirty were project managers. The response rate of survey forms was found to be 43% with 30 contractors and 13 project management personals completing the form and returning it. A five-point Likert scale was used for rating every risk factor. The organization risk premium index was used for analyzing survey data. The top five risks found in the UK construction industry were contractual arrangements, financial stability, construction-related, market/industry, project (design information).

Ghosh and Jintanapakanont (2004) identified critical risk factors involved in underground rail projects in Thailand. A questionnaire survey was designed consisting of 59 risk factors based on literature. These factors were focused on risk factors that was affecting the overall project costing, completion time & specifications. Factor-analysis approach

was used analyzing survey data. A five-point Likert scale was used for rating every risk factor. The questionnaire was distributed to 150 respondents out of which 122 completed forms were received back. Respondents included project managers, site supervisors, engineers, architects, project operation officers. The top five identified risk factors in Thailand underground rail work were delay in completion risk, finance problems and economic risk, risk related to subcontracting, contract and legal system-related risks, design-related risk.

Wang, Dulaimi, and Aguria (2004) focused on the risk management framework in developing countries for construction projects. A questionnaire survey was developed consisting of 28 critical risk factors. These risk factors were divided into 3 levels- country level, market level & project level. The main purpose of this research is to make a risk management framework that can be used in construction work in developing countries for positive outcomes. A risk model was proposed named Alien Eyes, which shows different levels and breakdown of risks. 22 risks were found to be critical out of 28 risk factors based on a 7-degree rating system. Mitigation measures were suggested and checked for each and every risk factor. The top five risks in developing countries were found to be: approval and permission by government, law changes in between of the project, unreliability and delay in justice, local partners creditworthiness, and instability of the political parties.

Bing, Akintoye, Edwards, and Hardcastle (2005) studied allocation of the risk in UK in PPP/PFI construction projects using a question-survey technique. The findings of this research will help construction practitioners to create better allocation of risk frameworks in the initial stages. After analysis of the survey data, it was clear that either risk was from public sector or it was shared with the private sector. Risks were classified into three levels: macro, meso, micro. Post was used to send 500 questionnaires, out of which 61 were returned and only 53 were useful for analysis relating to risk allocation. The findings of the research show that site-related risk, as well as risk related to political issues, should be checked by public sector. Legislation and relationships risks should be retained by both the parties. Private sector should be responsible for the meso-risks.

Zou, Zhang, and Wang (2007) identified key risks present in the construction industry of China. Risks were ranked based on their effect on the project objectives (cost-overrun, time-delays, environment, quality issues, safety, etc.) and life cycle of a project. Questionnaire survey method was used for collecting data. A total of 177 survey forms was distributed out of which 86 (46% response rate) was received back and 83 was found valid for data analysis, top 25 risk factors were determined. The survey feedback consists of two parts- the frequency of occurrence and severity of consequences. The conclusion of this research was that everyone should be clear about their responsibilities from the starting stage of the project. This finding was compared with another similar study done in Australia. The unique and top 5 risks in the Chinese construction industry were- problem of funds, lack of experience of contractor in proper management of the project, reimbursement difficulty, no insurance policies taken and no attention towards construction safety and pollutions.

El-Sayegh (2008) examined the risk in the UAE construction industry. A questionnaire survey was designed for this study, consisting of 42 risk factors prepared based on earlier studies in Kuwait, Indonesia, Hong Kong, USA, and China. 200 questionnaire surveys were distributed out of which 70 was received back and 65 completed survey forms were used for analysis. The relative importance index model was used for prioritizing risks depending upon the frequency of the risk and the impact of risk on objectives of the project. Risk factors were classified as internal risk and external risk. Further internal risks were divided into 5 categories- owners related, designers related, contractors related, sub-contractors related, suppliers related and external risks were also classified into 5 categories- political risk, social & cultural risk, economic risk, natural risk, others. The top five important risks in construction industry of the UAE were- inflation in prices, tight schedule to complete project, subcontractors improper management, and less productivity, delay and shortage of material, design changes by owners. Least significant risks in UAE construction industry were political, cultural and social risks.

Zavadskas, Turskis, and Tamosaitiene (2010) studied assessment of risk in the construction projects. The assessment was done on multi-attribute decision-making methods. In this paper, the risk was divided into three groups- external, project, internal. Only those risk attributes were selected that affect the construction and real estate industry. TOPIS grey and COPRAS-G methods were used for ranking and determining the optimality of different attributes. The proposed model can be used for avoiding negative impacts and increasing the chances of positive outcomes. Decision making has an significant role in construction management. The results of the research show different levels of construction projects and if a risk assessment is done properly, loses can be minimized.

Subramanyan, Sawant, and Bhatt (2012) examined construction risk in construction industry of the India. 93 risk factors were recognized by reviewing literature and these risk factors were listed under various subgroups. All these risk factors were included in the questionnaire and were filled by 15 respondents having experience of more than 20 years in the Indian construction industry. For analysis purposes, fuzzy Analytical Hierarchy Process (AHP) was used. The risk was divided into two groups: the first group includes contractor, project manager, owner, resource-specific risk and other group include risk related to environment, consultant, contract-clause, etc. The mitigation measures suggested in this paper are useful if applied in a proper manner, it can increase the chances of positive outcomes.

El-Sayegh (2008) used a questionnaire survey technique to gather data for analysis. The study was focused on bridge construction in Pakistan. Thirty-seven risk factors were considered for survey purpose. Seventy-seven filled forms were received and out of which sixty-nine was complete & usable for analyzing data. Further, these thirty-seven risks were categorized into seven categories- financial risks, design-related risks, health risks, contractual risks, management risks, construction risks, external risks. Relative importance index and Monte Carlo Stimulation was used for analyzing survey data. The financial category was found to topmost category affecting cost and schedule objectives. The top five risks for bridge construction in Pakistan were unavailability of funds, lack of clarity over roles, lack of funds, inadequate site investigation, and inadequate project planning.

Serpella, Ferrada, Howard, and Rubio (2014) identified that for proper and productive risk management a good methodology, information & experience in that field is required. This research is based on the Chile construction industry which shows both, owners, as well as contractors, never use risk management practices properly which results in a negative outcome and losses. In this paper knowledge-based approach is used and a three-fold methodology is proposed consisting of, risk management model, its assessment, and the use of a best practices model. Initial conclusion was that risk management is still very unsuccessful due to lack of knowledge of risk involved in the construction practices. The use of the proposed approach will help contractors and clients to deal with risk in a better way and avoid losses. Further, this risk management model can be improved by taking more things into account depending on a particular project or specific location.

Ameyaw and Chan (2015) evaluated and ranked various risk factors in PPP water supply projects using fuzzy approach in developing countries. A 40-factor risk list was prepared as a questionnaire survey forms. These risks were based on previous literature and case studies in developing countries. All these 40 factors were divided into 3 main factors- financial and economic, legal and social and political, and technical. A seven-point rating system was used in this survey. Probability and severity mean scores were computed separately and then the effect of the risk factor is calculated by taking the square root of multiplication of frequency and severity. The top five risks found were unpredicted exchange rate, corruption, and bribes, water stealing, delay in payment, political issues.

Iqbal, Choudhry, Holschemacher, Ali, and Tamosaitiene (2016) studied risk management in construction projects. The study was based on the Pakistan construction industry. For this study, a questionnaire survey was prepared to consist of 37 risk factors. Research was based on finding the significance of different risk factors, ultimately responsible for them. The age score was calculated for each of the risk factors having the same formula as the relative importance index. The risk was classified based on the responsibility of that risk that is contractor, client and on shared bases. Two risk management techniques were used: preventive technique and remedial technique. The top 5 risks involved in the Pakistan construction industry were: payment delays, defective design, lack of funds, accidents in between construction, low performance.

Dandage, Mantha, and Rane (2018) evaluated risk categories ranking in international projects. TOPSIS technique was used for ranking of the risk categories. The main purpose of this study was to identify major risk categories which affect the project success. Literature review was used for preparing questionnaire survey. Then the survey data was analyzed using TOPSIS for ranking of risk category according to their importance. Eight risk categories were identified and top three categories were namely- political, technical and related to design. This study will help risk managers to manage risk in an improved manner.

Yu, Chan, Chen, and Darko (2018) identified critical risk factors of transnational PPP projects. A literature review technique was used and 37 articles on TPPP were studied for this research. Selected articles were from 1991 to 2015. The most commonly used methods for the study of TPPP were found to be case studies, surveys, discussions, hybrid methods, etc. The top 5 identified risks were legal risk, tariff risk, cooperation risk between public and private sector, financing risk, and political risk. A checklist is also developed of TPPP critical risk factors that can be used for further research studies and analysis. Checklists are also helpful in understanding risk before it occurs and managing it for

better results. Further scope of this research is more papers can be included related to TPPP. Software tools can also be used for analyzing data.

Siraj and Fayek (2019) identified common risks in the construction industry. The risk was categorized into following categories (management, environmental, construction and resource-related, technical, contractual & legal related, economic & financial related, social, political, site conditions, health-safety) consisting of 10 risks in each category, that means a total of 110 risk factors was considered. Based on the number of articles considering these risks all the risks were ranked in their individual category as well as overall top 10 risks. for this analysis, a total of 130 articles was selected. Most of the selected articles were considering infrastructure projects in regions of Asia and Europe. The top risks identified from this research were design errors, change in the inflation rate, bad engineering practices, change in government laws in between of the project affecting outcomes.

Willumsen, Oehmen, Stingl, and Geraldi (2019) focused on management of risk to add value to the project. In this paper review of literature and empirical study was done to add value to project. Interviews of experts and qualitative analysis was done for empirical study. It was found that stakeholders perception plays an important role in giving importance to a particular item. The results indicate that there is a need of better understanding of different risks according to stakeholders perception as it adds more value to risk management process. Risk management creates value to the project in terms of project outcomes as well as it tells how threatened was the value of risk. Sometimes to win a tender risk manager ignore the risks involved in a project. Still, there is lack of knowledge of managing risk in construction industry which results in lot of losses in terms of cost, time, quality, etc.

Ugwu, Osunsanmi, and Aigbavboa (2019) examined risk management practice in construction industry of Nigeria. Construction plays an important role in enhancing economic growth. Every construction project some sort of risks. These risks cannot be removed and can only be managed. For this study quantitative approach was used as it is based on experience, knowledge, opinion, beliefs of an expert in the field. A total of two-hundred questionnaire was sent and only one-fifty was valid for the analysis. SPSS was used for the analysis of data using factor analysis approach. The results show that risk can be managed by proper identification of risk, its management, and control. Risk mitigation measures also play an important role in successful completion of project.

Viswanathan, Tripathi, and Jha (2019) studied the effect of risk mitigation measures on success of the international construction projects in Indian scenario. Literature review technique was used to identify nine mitigation measures for risk and three success criteria for the projects namely- performance of cost, schedule, and firm. Factor analysis and structural equation modeling was used for modeling and analysis of data obtained from questionnaire survey of 105 respondents. Three correlated risk mitigation measures were identified namely- pre-planning of project, participation of local people and selection of contract. This paper focuses on developing a risk mitigation model which can be used to deal with different risks involved. The finding of this research will help construction practitioners to improve success rate of projects in India and similar countries.

RESULTS AND DISCUSSIONS

On the basis of the literature review, various methods of risk classification were identified as shown in Table 1, the most commonly used method for classification of risk is based on the nature of risk i.e. based on the risk category (management, technical, finance, etc.). These methods of classifying risk will help in managing risks in a proper manner as this categorization explains clearly which party is responsible for a particular risk.

Table 1 *Risk Classification Methods*

S.No.	Risk Classification Methods	Example
1	The initial source of risks	Internal or external
2	Nature of risks	Management, financial, etc.
3	Occurrence of risks at various levels of the project	Planning, design, etc.
4	The originator of the risk	Client, contractor, etc.
5	No classification	Listing risk directly

Generally used risk identification techniques are shown in Table 2, In this paper, the most commonly used risk identification technique was a questionnaire survey, literature review, Brainstorming and Delphi technique. As in most of the articles, the questionnaire was prepared with the help of reviewing literature. Risk should be regularly identified in a construction project. As new risks keep on emerging in construction projects as project proceeds. So new risks should be added as soon as identified and proper mitigation plans should be prepared.

Table 2 *Risk Identification Techniques*

S.No.	Tools and Techniques Used
1	Questionnaire survey
2	Literature review
3	Brainstorming and Delphi technique
4	Expert interview and Checklist
5	Past projects/historical project data
6	Documentation review

Critical risk factors were recognized based on literature and are classified on the basis of the nature of risk as it is the most commonly used method for classification of the risk. The top ten critical risk factors were considered on the basis of the number of articles considering that risk in their analysis. So, here out of 67 critical risk factors identified from previous studies, these are the top ten risks that are present in the construction industry.

Table 3 *Top Ten Risks Identified from the Literature*

S.No.	Risk Factor	Nature of Risk
1	Unavailability of funds	Financial risk
2	Design errors and poor engineering	Technical risk
3	Poor site management	supervision& Management risk
4	Contractual risks	Legal risk
5	Laws and regulations changes	Political risk
6	Severe environmental conditions	Environmental risk
7	Change in inflation rate	Financial risk
8	Natural disaster	Environmental risk
9	Inadequate safety measures	Health & Safety risk
10	Change in project scope	Legal risk

CONCLUSION AND IMPLICATIONS

This paper examined the top risk factors, risk identifying techniques and methods of classifying risk for construction projects. For any particular projects, like building projects, infrastructure projects, power projects, etc. risk may slightly vary as research done here is in general for construction projects which covers a wide range of projects. Risks may vary for a particular project depending on its nature, location, size, investment, etc. It is clear from the above study that knowledge of risk management is still very less among the construction industry. Therefore, it results in huge losses in terms of time, cost and quality. The top ten risks identified are unavailability of funds, design errors and poor engineering, poor site management & supervision, contractual risks, laws and regulations changes, severe environmental conditions, change in the inflation rate, natural disaster, inadequate safety measures, change in project scope. The most commonly used method for classification of risk was based on the nature of risk and the most commonly used tool & technique for risk identification was a questionnaire survey & literature review. These findings are valuable to the construction industry and researchers also.

As this study covers risks involved in construction projects which is a wide area as already discussed. Further scope of this study is that the same analysis can be done project-specific i.e. for different types of projects example- building, infrastructure, nuclear and power, etc. as risks may slightly differ. This research can also be done on region-specific i.e. depending on location of the project, as risks are different for same projects at different locations. Risk also varies for different projects depending upon investment; therefore, another factor can be considered in this research is cost involved. Considering the above-said factors will result in more accurate risk identification and management.

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